LFG COLLECTION EFFICIENCY IS IMPROVING IN WISCONSIN

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ABSTRACT
Wisconsin has 32 landfills that actively receive municipal solid waste (MSW). Twenty-four (24) of these landfills are required to collect landfill gas (LFG) via active landfill gas collection and control systems (GCCS). A study was conducted by Shaw and Waste Management (WM) to determine how the LFG collection efficiency at these 24 landfills is changing over time.

The LFG industry has long struggled with calculating the "real" LFG collection efficiency. While this study does not supply the "real" LFG collection efficiency, it does utilize a qualitative approach to track efficiency over time to reveal trends in the data. This is the first study of its type to review LFG collection efficiency trends on a statewide level. This approach can be replicated by other States to determine their statewide LFG collection efficiency trend and to help focus on sectors that need improvement.

Results of this study confirm that Wisconsin's' LFG collection efficiency is improving (refer to Table 1). For the years 2000 through 2004, the statewide LFG collection efficiency continuously improved from 77.3% to 85%. Further subdivision of the 24 landfills was made into 2 groups: 1) landfills owned by private industry, and 2) landfills owned by municipalities. These results are also reported in Table 1.

Wisconsin's 24 landfills accepted over 7.5 million tons of decomposable waste in year 2004. This tonnage data, dating back to Year 1988, was input into the EPA LANDGEM model to estimate the statewide LFG generation. Wisconsin landfills were then contacted to obtain their annual LFG collection rates for the years 2000 through 2004.

This study concluded that:

- LFG collection efficiency in Wisconsin is improving over time, even as more and more waste is deposited in landfills every year.
- The 2004 LFG collection efficiency at 24 landfills averaged 85%.
- The LFG collection efficiency of the privately owned and municipally owned landfills in Wisconsin is generally the same.

Table 1 – Wisconsin's Trend in LFG Collection Efficiency

Year	EPA LFG Generation Rate k =.04 & Lo =100 (scfy)	LFG Collection Rate (scfy)	LFG Collection Efficiency
All 24 Landfills			
2000	11,011,536,242	8,510,869,218	77.3%
2001	12,186,264,192	9,649,623,435	79.2%
2002	13,515,657,032	10,879,087,006	80.5%
2003	14,697,752,437	11,828,449,205	80.5%
2004	15,846,366,701	13,476,494,679	85.0%
Total	**67,257,576,605**	**54,344,523,542**	**80.8%**
9 Municipally Owned Landfills			
2000	2,753,612,886	2,023,757,382	73.5%
2001	2,916,809,855	2,265,507,691	77.7%
2002	3,035,436,221	2,280,396,975	75.1%
2003	3,158,481,798	2,451,376,080	77.6%
2004	3,275,611,698	2,717,645,580	83.0%
Total	**15,139,952,458**	**11,738,683,707**	**77.5%**
15 Privately Owned Landfills			
2000	8,257,923,356	6,487,111,836	78.6%
2001	9,269,454,337	7,384,115,744	79.7%
2002	10,480,220,811	8,598,690,031	82.0%
2003	11,539,270,640	9,377,073,125	81.3%
2004	12,570,755,004	10,758,849,099	85.6%
Total	**52,117,624,147**	**42,605,839,835**	**81.7%**

DEFINITION OF LFG EFFICIENCY

A rigorous approach to calculating landfill gas efficiency would be to conduct field test with devices, such as flux chambers, over wide-spread areas of a landfill and for several seasons. In this study it is not necessary to determine the "real" collection efficiency, but to use a qualitative approach to reveal trends in state-wide landfill gas collection efficiency over time. The general approach used here to determine landfill gas collection efficiency is to divide the LFG collected by the LFG that is generated. LFG collected is quite simple to determine based on flow meters installed just prior to the control equipment. Estimating LFG generation is much more involved due to the abundance of uncertainties and variables. As stated, field data was not collected for this paper in order to determine LFG generation rates; instead computer modeling was done.

Computer modeling of LFG generation has long been known to be uncertain. In order to minimize modeling uncertainty, all landfills were reviewed as a single facility and an average "k" and "Lo" was used in EPA's LANDGEM model.

This averaging approach normalizes the fact that all landfills in the State have different LFG generation characteristics (such as: moisture, pH, particle size, waste types, etc...) and allows a qualitative assessment of LFG collection efficiency trends over time. Since the purpose of this study was to use a qualitative approach, the trends are real but the specific LFG collection efficiencies reported herein should be scrutinized.

BACKGROUND

This section summarizes the current rules requiring LFG collection at Wisconsin landfills and Wisconsin Department of Natural Resources (WDNR) draft program to increase LFG collection efficiency. Wisconsin Administrative Code NR 500 requires municipal solid waste landfills in the State to install and operate landfill gas collection systems if the design capacity of the landfill is greater than 500,000 cubic yards. US EPA new source performance standards (NSPS) and emission guidelines (40 CFR 60.752) requires municipal solid waste landfills with a design capacity greater than 2.5 million megagrams, and with emission greater than 50 Mg/year of non-methane organic compounds to install and operate a LFG collection system.

In year 2003, WDNR adopted an environmental management system (EMS) as apart of ISO 14000 certification. This EMS established goals for the Bureau of Solid Waste that moved them beyond compliance. One goal of the Bureau of Solid Waste EMS was to voluntarily reduce the uncontrolled release of LFG emissions from active landfills (i.e.: improve the efficiency of LFG collection systems). WDNR's draft guidance indicates more than 85% collection efficiency is desired. WDNR's guidance also indicates that the use of the EPA LANDGEM model or surface emission monitoring is the desired approach to make this demonstration.

In order to assess the impact of WDNR's desired LFG collection efficiency on Wisconsin landfills a review of existing LFG collection efficiency was needed. This paper should be considered the first step in assessing existing LFG collection efficiency for landfills located in the State of Wisconsin.

APPROACH

The approach taken to prepare this paper was:

1. Tabulate the tonnage of decomposable waste (i.e.: waste that generates LFG), since 1988, that was disposed in Wisconsin landfills;
2. Estimate the amount of LFG generated using the EPA LANDGEM model and the amount of decomposable waste;
3. Tabulate the amount of LFG actually collected at Wisconsin landfills; and
4. Calculate and review the historic LFG collection efficiency.

In order to be consistent with the WDNR's EMS, the only landfills considered in this assessment were the ones that met all of the following criteria:

- Landfills that received decomposable municipal solid waste (no papermill monofills were considered), and
- Landfills that accepted waste in Year 2003 (start of the WDNR's EMS), and
- Landfills that were federally or State required to have an active LFG collection system in the year 2003.

Utilizing these criteria, a total of 24 landfills were considered in this assessment. These landfills include nine municipally owned and 15 privately owned landfills.

WASTE TONNAGE

This section summarizes the amount of decomposable waste that is deposited in Wisconsin landfills. This data is used in subsequent sections of this paper to estimated LFG generation rates. In Wisconsin, solid waste permits require that landfills report waste tonnage deposited by various categories. Waste tonnage information was supplied by WDNR in the form of Microsoft EXCEL spreadsheets.[1] Each MS EXCEL spreadsheet contained a single year of tonnage data for all landfills in the State. The data was sorted to include only the landfills that met the criteria noted above and the data was filtered to include only decomposable waste materials.

[1] Some of the WDNR supplied tonnage information may not have included corrections for recycling.

Waste materials included as decomposable are: MSW, pulp/papermill, POTW sludge, and "other". The inclusion of all "other" waste may introduce some error[2] because not all parts of that waste are completely decomposable. Waste types not included in this assessment, because they are believed to not contribute to LFG generation were: ash, foundry waste, fee exempt waste, industrial waste used for daily cover, shedder fluff, and contaminated soils.

Tonnage data from Year 1988 to 2004 was considered in this assessment. While the waste from prior to Year 1988 may also be generating small amounts of LFG flow, it is believed that the amount of LFG contribution from this old waste is insignificant due to it age. In addition, the way waste tonnage was reported prior to 1988 is not as accurate as more recent data due to the changes in waste category definition over time. Therefore, not considering waste older than Year 1988 in this assessment is not considered to significantly impact the results.

A year by year summary of the decomposable waste deposited in Wisconsin landfills is provided in Table 2 and a graphic of the waste tonnage is shown in Figure 1. Based on the tonnage data provided by WDNR, nearly 87 million tons of decomposable waste was deposited in these 24 landfills from Year 1988 thru 2004.

Nearly half of the decomposable waste deposited during this period is deposited in six landfills (i.e.: ONYX Emerald Park, Republic Kestrel Hawk, Republic Mallard Ridge, WM Metro, WM Orchard Ridge, and WM Pheasant Run). These six landfills are all located in the southeastern portion of Wisconsin.

During the period of analysis (1988 thru 2004), 21% by weight of the decomposable waste went to municipally owned landfills, 79% went to landfills owned by private companies (WM, Republic, Allied, and Onyx). Refer to Table 2 for a year by year summary of the waste tonnage at every landfill considered in this paper.

ESTIMATES OF LFG GENERATION

This section of the paper predicts how much LFG is generated from all Wisconsin landfills including subsets: 1) privately owned landfills, and 2) municipally owned landfills. Determining the amount of LFG generated involved modeling with numerous assumptions. Research has shown that the amount of LFG generated varies depending on many items, but primarily the type/quantity of waste and the moisture content of the waste. Other factors that have less significance but are still important to LFG generation include: pH, landfill temperature, and waste particle size.

[2] This error may result in an over prediction of LFG generation and the reporting herein of a lower than actual LFG collection efficiency.

These estimates were prepared using a computer model created by USEPA (LandGEM). LandGEM is based on a first-order decomposition rate equation for quantifying emissions from the decomposition of landfilled waste in municipal solid waste (MSW) landfills. The software provides a simple approach to estimating landfill gas emissions. EPA recommends that LANDGEM not be used for determining LFG collection efficiency, however, since WDNR adopted it for their EMS, this is the method used in this paper.

The LandGEM model requires only three inputs, as follows: annual waste tonnage, "k" (the methane generation rate), and "Lo" (methane generation potential). Annual waste deposited from year 1988 through year 2004 in Wisconsin was utilized as described in the previous section of this paper. EPA's LandGEM model recommends a "k" value of 0.02 per year to 0.07 per year. Due to the average amount of rainfall received in Wisconsin, as compared to the other 50 States, a "k" value of 0.04 was selected for this paper. EPA's LANDGEM model recommends a "Lo" value of 96 to 170 cubic meters per megagram of waste and indicates the more organic waste in the landfill waste stream results in a higher "Lo". A Lo of 100 was selected for this paper. A k of 0.04 and Lo of 100 are considered by EPA as the AP-42 defaults and EPA believes these are representative of the average landfill in the USA. This author believes that a k of 0.04 and Lo of 100 are reasonable modeling assumptions for reviewing Wisconsin LFG generation, as a whole. However, this author does not believe this k and Lo values should be used to model individual landfills because the waste moisture and waste types vary too much from landfill to landfill.

Results for All Landfills.

Results of modeling the LFG generation rate for all 24 of the Wisconsin landfills are shown in Table 3. This modeling indicates that over 15.8 billion cubic feet of LFG was generated in 2004 from the 24 landfills considered in this paper.

Results for Municipally Owned Landfills.

Results of modeling the LFG generation rate for all nine of the Wisconsin municipally owned landfills are shown in Table 4. The nine landfills modeled include: Brown County East, Dane County #2, City of Janesville, LaCrosse County, Marathon County, Outagamie County, Portage County, Sauk County, and Winnebago County. This modeling indicates that more than 3.2 billion cubic feet of LFG was generated in 2004 from the nine municipally owned landfills.

Results for Privately Owned Landfills. Results of modeling the LFG generation rate for all 15 of the Wisconsin privately owned landfills are shown in Table 5. This modeling indicates that more than 12.5 billion cubic feet of LFG was generated in 2004 from the 15 privately owned landfills.

Table 2 – Decomposable Waste Deposited in Wisconsin Landfills (tons / year)

Facility Name	WDNR Lic. No.	1988	1989	1990	1991	1992	1993	1994	1995	1996
Landfills that Were Active in Year 2003 and Have LFG Collection Systems In-place in Year 2003 - Private Owners										
ALLIED LAKE AREA	3144 & 3474	0	0	44,678	55,411	73,053	61,510	83,055	76,171	163,451
ONYX CRANBERRY CREEK	652 & 2967	75,069	85,622	93,503	127,808	114,236	110,645	102,617	105,158	124,122
ONYX EMERALD PARK	3290	0	0	0	0	0	0	16,217	238,376	495,675
ONYX GLACIER RIDGE	3068	42,480	42,480	50,000	70,000	129,358	283,648	308,478	206,196	284,635
ONYX HICKORY MEADOWS	3134	0	0	0	0	0	0	0	0	0
ONYX SEVEN MILE CREEK	2821 & 3097	63,800	58,507	54,787	56,758	53,433	51,633	49,502	48,286	20,814
REPUBLIC KESTREL HAWK	572	246,753	332,568	328,268	333,221	266,967	271,652	320,579	101,835	167,299
REPUBLIC MALLARD RIDGE	140 & 3244	72,601	115,693	124,913	197,743	246,741	177,585	312,176	238,482	293,787
W M DEER TRACK PARK	3230	0	0	0	0	29,819	74,061	116,686	182,129	258,915
W M METRO RDF	1099	302,211	345,461	427,117	407,148	542,083	500,947	462,307	352,392	412,532
W M ORCHARD RIDGE & PARKVIEW	3360 & 3108	0	210,533	504,775	533,188	578,445	589,359	604,491	601,676	358,846
W M PHEASANT RUN	3062 & 3765	272,158	332,543	260,539	270,811	294,130	306,837	418,599	209,828	442,082
W M RIDGEVIEW	3041	102,358	144,969	185,600	185,350	236,925	233,247	230,801	263,132	236,679
W M TIMBERLINE TRAIL	3455	0	0	0	0	0	0	0	70,076	157,621
W M VALLEY TRAIL	3066	61,206	95,485	117,427	220,319	201,356	348,182	345,525	298,019	327,819
All Privately Owned Landfills SUBTOTAL		1,238,635	1,763,861	2,191,607	2,457,758	2,766,546	3,009,307	3,371,033	2,991,756	3,744,277
Landfills that Were Active in Year 2003 and Have LFG Collection Systems In-place in Year 2003 - Municipal Owners										
BROWN CNTY EAST LF	2569	116,756	116,535	186,174	179,621	147,842	147,080	194,793	136,510	147,812
DANE CNTY LF #2 RODEFELD	3018	229,582	251,156	261,366	170,376	153,931	163,378	126,969	122,025	107,604
JANESVILLE CTY - ROCK CNTY LF	3023	92,766	117,757	118,179	117,808	118,476	121,807	122,931	103,343	128,192
LA CROSSE CNTY	2637	20,962	26,352	42,703	41,433	33,119	33,256	37,173	34,080	34,960
MARATHON CNTY LF AREA A	2892	96,634	140,650	159,959	127,610	141,727	129,362	124,670	115,835	126,552
OUTAGAMIE CNTY SW DIV LF	2484	284,251	287,473	230,475	234,779	245,249	239,280	246,335	249,845	201,107
PORTAGE CNTY LF	2966	27,601	29,394	31,356	33,210	33,189	33,626	33,622	29,640	28,438
SAUK CNTY LF	2978	32,567	28,437	29,998	30,362	32,745	26,118	28,403	31,323	23,324
WINNEBAGO CNTY SUNNYVIEW LF	3175	0	139,490	289,702	307,479	338,093	290,269	272,380	197,807	201,933
All Municipally Owned Landfills – SUBTOTAL		901,119	1,137,244	1,349,912	1,242,678	1,244,371	1,184,176	1,187,277	1,020,408	999,922
GRAND TOTAL		2,139,754	2,901,105	3,541,520	3,700,435	4,010,917	4,193,483	4,558,310	4,012,164	4,744,199

Table 2 (continued) – Decomposable Waste Deposited in Wisconsin Landfills (tons / year)

Facility Name	WDNR Lic. No.	1997	1998	1999	2000	2001	2002	2003	2004	TOTALS
Landfills that Were Active in Year 2003 and Have LFG Collection Systems In-place in Year 2003 - Private Owners										
ALLIED LAKE AREA	3144 & 3474	106,305	52,062	106,362	0	0	269,598	378,736	575,429	2,045,821
ONYX CRANBERRY CREEK	652 & 2967	127,344	143,661	232,284	223,803	427,500	249,926	251,440	226,873	2,821,611
ONYX EMERALD PARK	3290	614,363	744,850	593,117	491,543	652,695	452,124	391,490	443,306	5,133,757
ONYX GLACIER RIDGE	3068	315,832	323,113	289,243	369,140	382,347	275,020	216,968	243,767	3,832,704
ONYX HICKORY MEADOWS	3134	0	0	109,800	220,305	346,256	384,735	359,599	362,117	1,782,813
ONYX SEVEN MILE CREEK	2821 & 3097	128,742	172,409	195,137	226,490	350,509	295,552	290,078	257,568	2,374,005
REPUBLIC KESTREL HAWK	572	149,900	222,845	298,931	423,291	597,902	420,633	445,383	455,026	5,383,052
REPUBLIC MALLARD RIDGE	140 & 3244	312,178	268,113	176,794	200,921	198,583	322,310	286,430	291,256	3,836,306
W M DEER TRACK PARK	3230	245,454	253,666	313,917	315,348	364,021	382,746	368,987	360,521	3,266,270
W M METRO RDF	1099	426,769	550,371	576,772	352,193	450,235	666,237	709,399	739,568	8,223,742
W M ORCHARD RIDGE & PARKVIEW	3360 & 3108	367,657	448,842	555,483	710,211	768,607	660,794	696,696	673,083	8,862,687
W M PHEASANT RUN	3062 & 3765	824,032	792,597	885,649	767,189	684,997	546,808	610,488	1,088,964	9,008,252
W M RIDGEVIEW	3041	322,709	417,851	444,658	469,421	421,086	396,153	395,347	388,507	5,074,792
W M TIMBERLINE TRAIL	3455	274,429	223,273	214,921	209,259	224,205	228,807	220,560	243,489	2,066,639
W M VALLEY TRAIL	3066	432,676	377,089	272,995	314,112	371,270	275,558	260,739	263,498	4,583,274
All Privately Owned Landfills SUBTOTAL		4,648,389	4,990,742	5,266,063	5,293,225	6,240,214	5,827,001	5,882,340	6,612,972	68,295,726
Landfills that Were Active in Year 2003 and Have LFG Collection Systems In-place in Year 2003 - Municipal Owners										
BROWN CNTY EAST LF	2569	202,184	162,723	188,657	174,638	160,777	145,521	63,333	0	2,470,956
DANE CNTY LF #2 RODEFELD	3018	118,947	116,778	133,132	126,555	140,794	127,345	135,009	167,053	2,652,000
JANESVILLE CTY - ROCK CNTY LF	3023	131,469	120,817	135,155	129,691	120,729	119,667	120,800	132,375	2,051,963
LA CROSSE CNTY	2637	34,689	40,329	40,503	46,365	40,861	44,402	38,660	41,591	631,436
MARATHON CNTY LF AREA A	2892	133,563	125,192	131,973	133,545	93,641	83,104	72,391	77,226	2,013,634
OUTAGAMIE CNTY SW DIV LF	2484	210,494	207,112	231,244	170,826	157,229	181,991	397,494	496,218	4,271,402
PORTAGE CNTY LF	2966	30,360	31,893	36,369	44,200	27,917	27,474	31,206	0	509,495
SAUK CNTY LF	2978	24,286	32,281	40,929	36,806	30,183	63,156	75,906	68,346	635,170
WINNEBAGO CNTY SUNNYVIEW LF	3175	219,753	196,249	176,466	212,279	151,463	166,890	20,425	16,312	3,196,990
All Municipally Owned Landfills - SUBTOTAL		1,105,745	1,033,374	1,114,427	1,074,905	923,593	959,549	955,225	999,122	18,433,048
GRAND TOTAL		5,754,135	6,024,117	6,380,490	6,368,130	7,163,807	6,786,550	6,837,564	7,612,094	86,728,774

Figure 1 - Decomposible Waste Deposited In Wisconsin Landfills That Were Actively Receiving Waste in Year 2003 & Required To Have an Active LFG Collection System

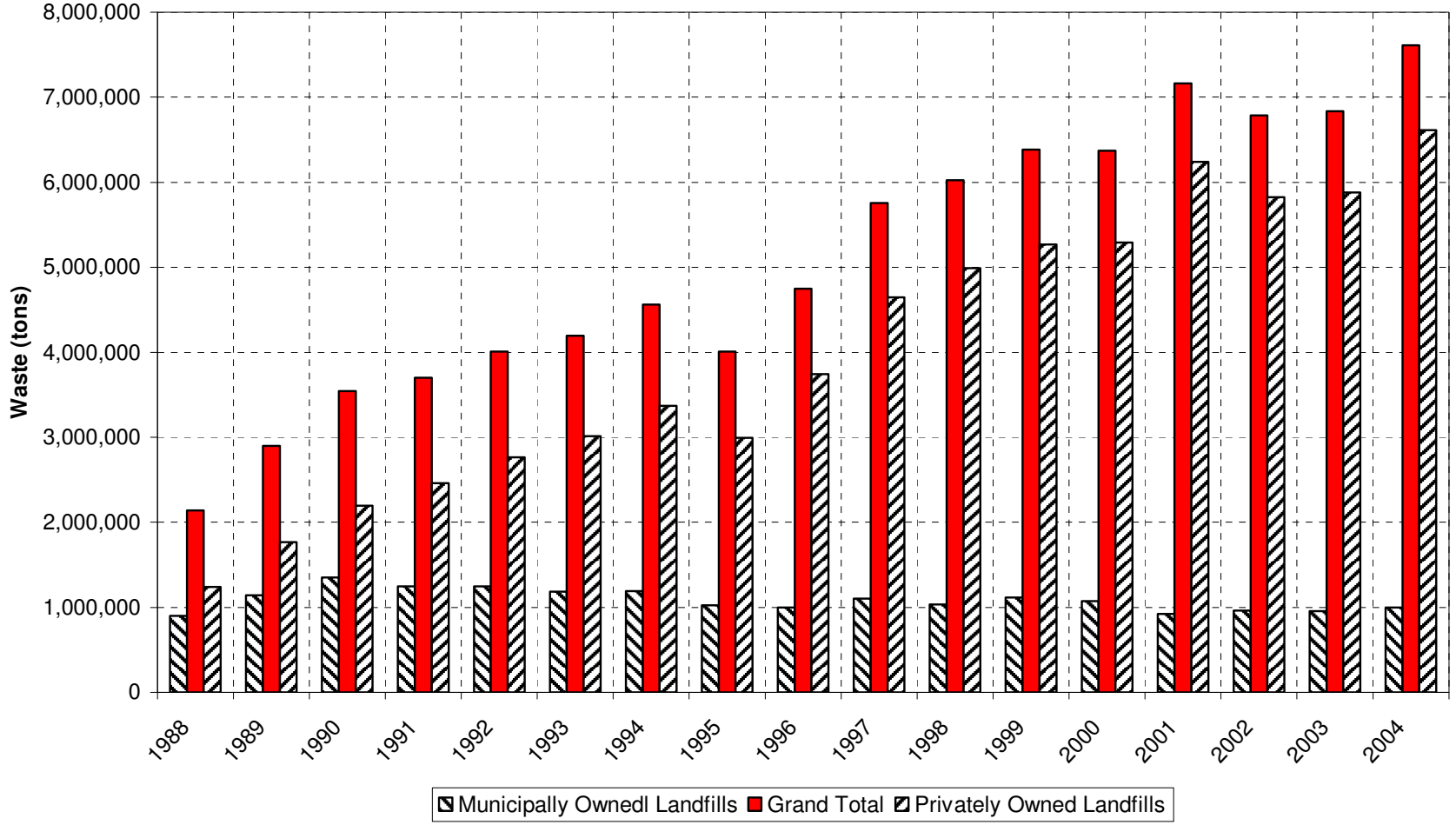

Table 3 – Total Estimated LFG Generation at 24 Wisconsin Landfills

Year	Annual Refuse Acceptance Rate (tons)	Cumulative Refuse Acceptance Rate (tons)	EPA LFG Generation Rate k=.04 & Lo =100 (scfy)
1988	2,139,754	2,139,754	0
1989	2,901,105	5,040,860	539,798,610
1990	3,541,520	8,582,379	1,250,498,505
1991	3,700,435	12,282,815	2,094,889,567
1992	4,010,917	16,293,732	2,946,261,489
1993	4,193,483	20,487,214	3,842,576,256
1994	4,558,310	25,045,524	4,749,802,070
1995	4,012,164	29,057,688	5,713,490,464
1996	4,744,199	33,801,887	6,501,615,254
1997	5,754,135	39,556,022	7,443,508,589
1998	6,024,117	45,580,139	8,603,247,583
1999	6,380,490	51,960,629	9,785,621,249
2000	6,368,130	58,328,759	11,011,536,242
2001	7,163,807	65,492,566	12,186,264,192
2002	6,786,550	72,279,116	13,515,657,032
2003	6,837,564	79,116,680	14,697,752,437
2004	7,612,094	86,728,774	15,846,366,701

All LFG generation rates are normalized to 50% methane

Table 4 – Estimated LFG Generation at Nine Wisconsin Municipal Landfills

Year	Annual Refuse Acceptance Rate (tons)	Cumulative Refuse Acceptance Rate (tons)	EPA LFG Generation Rate k=.04 & Lo =100 (scfy)
1988	901,119	901,119	0
1989	1,137,244	2,038,363	227,326,404
1990	1,349,912	3,388,275	505,306,898
1991	1,242,678	4,630,953	826,037,683
1992	1,244,371	5,875,324	1,107,140,222
1993	1,184,176	7,059,500	1,377,647,860
1994	1,187,277	8,246,777	1,622,363,142
1995	1,020,408	9,267,185	1,858,265,283
1996	999,922	10,267,107	2,042,821,354
1997	1,105,745	11,372,852	2,214,972,707
1998	1,033,374	12,406,227	2,407,070,241
1999	1,114,427	13,520,654	2,573,378,406
2000	1,074,905	14,595,559	2,753,612,886
2001	923,593	15,519,153	2,916,809,855
2002	959,549	16,478,702	3,035,436,221
2003	955,225	17,433,926	3,158,481,798
2004	999,122	18,433,048	3,275,611,698

Table 5 – Estimated LFG Generation at 15 Wisconsin Privately Owned Landfills

Year	Annual Refuse Acceptance Rate (tons)	Cumulative Refuse Acceptance Rate (tons)	EPA LFG Generation Rate k=.04 & Lo =100 (scfy)
1988	1,238,635	1,238,635	0
1989	1,763,861	3,002,497	312,472,207
1990	2,191,607	5,194,104	745,191,607
1991	2,457,758	7,651,862	1,268,851,884
1992	2,766,546	10,418,407	1,839,121,267
1993	3,009,307	13,427,714	2,464,928,396
1994	3,371,033	16,798,747	3,127,438,929
1995	2,991,756	19,790,503	3,855,225,182
1996	3,744,277	23,534,780	4,458,793,900
1997	4,648,389	28,183,170	5,228,535,882
1998	4,990,742	33,173,912	6,196,177,341
1999	5,266,063	38,439,975	7,212,242,844
2000	5,293,225	43,733,199	8,257,923,356
2001	6,240,214	49,973,413	9,269,454,337
2002	5,827,001	55,800,414	10,480,220,811
2003	5,882,340	61,682,754	11,539,270,640
2004	6,612,972	68,295,726	12,570,755,004

All LFG generation rates are normalized to 50% methane.

LFG COLLECTION RATES

This section summarizes how much LFG has been collected since year 2000. Determining the actual amount of LFG collected is quite simple to obtain from flow meters installed by the landfill owners (assuming that the flow meters are accurate and properly calibrated).

LFG Collection for All Landfills.

Table 6 tallies the annual amount of LFG collected at all 24 landfills from year 2000 thru 2004. The data in Table 6 was obtained via various methods including: flow totalizer, average flow times operating hours, etc; each with varying degrees of accuracy. Each landfill manger transmitted their data to Shaw via email or personal communication. The results presented in Table 6 have not been corrected to 50% methane due to the unavailability of this information.

Sauk County Landfill is not included in Table 6 because Sauk County is not required by their WDNR permit to maintain total LFG flow records therefore Sauk County could not accurately provide this information. While excluding Sauk County from the tally does introduce some error into the assessment we believe this error is minor because Sauk County Landfill is very small and only accepted 635,170 tons of decomposable waste during the period of assessment (1988 to 2004) or only 0.73% of the total waste collected among all 24 landfills.

For all landfills, combined, the amount of LFG collected has increased every year such that for year 2004 the landfill owners have collected over 13.4 billion cubic feet of LFG.

LFG Collection for Municipally Owned Landfills.

Table 6 subtotals the annual amount of LFG collected at the 9 municipally owned landfills from year 2000 thru 2004. For these 9 landfills the amount of LFG collected has increased every year such that for year 2004 the municipal landfill owners have collected over 2.7 billion cubic feet of LFG. For years 2003 and 2004, Brown County East Landfill collected the most LFG, of the municipal landfills at 0.63 billion cubic feet in Year 2004.

LFG Collection for Privately Owned Landfills.

Table 6 subtotals the annual amount of LFG collected at the 15 privately owned landfills from year 2000 thru 2004. For these 15 landfills, combined, the amount of LFG collected has increased every year such that for year 2004 the private landfill owners have collected over 10.7 billion cubic feet of LFG. WM's Pheasant Run Landfill collected the most LFG in year 2004, at 1.7 billion cubic feet.

Table 6
LFG Collected At Wisconsin MSW Landfills With Active LFG Collection Systems
Total LFG Collected (SCF per Year)

Landfill	DNR License #	2000	2001	2002	2003	2004
Private Landfills						
ALLIED LAKE AREA	3144 & 3474	unknown	unknown	297,489,600	439,401,600	371,073,600
ONYX CRANBERRY CREEK	652 & 2967	677,000,000	706,000,000	603,000,000	607,000,000	571,000,000
ONYX EMERALD PARK	3290	345,000,000	349,000,000	563,000,000	685,000,000	715,000,000
ONYX GLACIER RIDGE	3068	400,000,000	511,000,000	545,000,000	534,000,000	572,000,000
ONYX HICKORY MEADOWS	3134	N/A	N/A	N/A	46,498,000	105,594,000
ONYX SEVEN MILE CREEK	2821 & 3097	472,514,400	590,248,800	630,720,000	643,860,000	662,256,000
REPUBLIC KESTREL HAWK	572	517,180,000	424,975,800	453,541,000	369,722,680	646,404,712
REPUBLIC MALLARD RIDGE	140 & 3244	328,805,910	274,798,670	344,342,500	375,408,200	390,039,300
WM Deer Track	3230	204,984,000	214,970,400	238,096,800	417,326,400	519,818,400
WM Metro	1099	1,447,513,000	1,463,094,000	1,343,956,000	1,253,654,000	1,354,986,000
WM Orchard Ridge	3360	347,421,600	579,211,200	760,543,200	599,184,000	801,014,400
WM Pheasant Run	3062 & 3765	905,340,000	1,047,694,000	1,273,946,000	1,653,000,000	1,711,000,000
WM Timberline Trail	3041	N/A	127,185,600	293,522,400	319,144,320	436,685,520
WM Ridgeview	3455	308,134,080	447,582,240	503,818,120	735,240,600	1,225,247,000
WM Valley Trail	3066	533,218,846	648,355,034	747,714,411	698,633,325	676,730,167
Subtotals Private		6,487,111,836	7,384,115,744	8,598,690,031	9,377,073,125	10,758,849,099
Municipal Landfills						
BROWN CNTY EAST LF	2569	486,180,000	433,620,000	433,620,000	473,040,000	630,720,000
DANE CNTY LF #2 RODEFELD	3018	312,382,182	300,161,091	303,233,455	315,504,000	348,262,420
JANESVILLE CTY - ROCK CNTY LF	3023	568,800,000	551,520,000	477,090,720	436,387,680	409,232,160
LA CROSSE CNTY - ROBINSON SITE	2637	52,500,000	52,500,000	105,000,000	105,000,000	105,000,000
MARATHON CNTY LF	2892	not available	233,175,000	218,930,000	322,828,000	356,765,000
OUTAGAMIE CNTY LF	2484	183,320,000	216,310,000	233,380,000	371,530,000	440,580,000
PORTAGE CNTY LF	2966	87,775,200	84,621,600	85,672,800	75,686,400	53,436,000
SAUK CNTY LF	2978	-	-	-	-	-
WINNEBAGO CNTY SUNNYVIEW LF	3175	332,800,000	393,600,000	423,470,000	351,400,000	373,650,000
Subtotals Municipal		2,023,757,382	2,265,507,691	2,280,396,975	2,451,376,080	2,717,645,580
	Grand Totals	8,510,869,218	9,649,623,435	10,879,087,006	11,828,449,205	13,476,494,679

TRENDING LFG COLLECTION EFFICIENCY

This section and Table 1 summarize the trend in Wisconsin's LFG collection efficiency from year 2000 to the end of 2004. From Years 2000 thru 2004, for all 24 landfills, the LFG collection efficiency improved by 7.7% (from 77.3% in year 2000 to 85% in 2004). This 5-year improvement in LFG collection efficiency resulted in 1.2 billion cubic feet of more LFG being collected in year 2004, had no improvement in LFG collection efficiency been made at all. Wisconsin landfill owners should be applauded for this improvement in LFG collection.

For years 2000 thru 2004, the LFG collection efficiency (for all sites combined and both the municipal and private subdivisions) was slightly better than EPA's AP-42 guidance which recommends an average LFG collection efficiency of 75.0%. Again, Wisconsin landfill owners are ahead of the average!

LFG collection efficiency in Wisconsin between the municipally owned and privately owned landfills is nearly the same; with the privately owned landfills having slightly better efficiency.

FINDINGS

The most significant findings of this paper are:

1. Over 7.5 million tons of decomposable waste was deposited in the 24 study landfills during 2004. Approximately 87% of this waste was deposited in 15 privately owned landfills and approximately 13% of this waste was deposited in 9 municipal landfills during year 2004.

2. In 2004, over 6.6 million tons of decomposable waste was deposited in 15 privately owned landfills and these 15 landfills collected nearly 10.8 billion cubic feet of LFG.

3. In 2004, nearly 1.0 million tons of decomposable waste was deposited in Wisconsin municipally owned landfills and the municipalities collected just over 2.7 billion cubic feet of LFG.

4. For the period of analysis (1998 thru 2004) approximately half the decomposable waste was deposited at six landfills located in the southeast part of the State of Wisconsin.

5. LFG collection efficiency at Wisconsin's 24 study landfills has improved nearly 8% since year 2000.

6. LFG collection efficiency at privately owned and municipally owned landfills has improved since year 2000 (7% and 9.5% respectively).

7. Comparing the calculated 2004 LFG collection efficiency to WDNR's EMS voluntary goal of 85%, shows that Wisconsin landfills have achieved the goal.

RECOMMENDATIONS

Recommendations for what can be done to refine the findings of this paper are as follows:

1. Normalize the actual methane concentration in the collected LFG to 50% methane; similar to the normalization that is done with LFG generation rates. Methane concentration data for normalization of the actual LFG flow was not available for this paper.

2. Some of the municipal landfills are not required by permit to totalize the LFG flow. Instead they reported an average flow times the operating time per year and estimate the annualized LFG flow.

3. Select a few landfills in the State for further study of the LFG collection efficiency. Instead of using the qualitative approach by modeling the LFG generation rate and calculating the LFG collection efficiency, as done in this paper, measure the flux of LFG escaping collection via: surface emission monitoring, flux boxes, FTIR, and other methods. Select landfills for this study that have a geo cap, geo liners, good history of waste tonnage and type, good history of actual LFG collected via flow totalizer, and measured methane concentrations in their collected LFG.

4. WDNR should factor the results of this paper into their EMS as follows:

   a. For year 2004 this study shows that Statewide 85% LFG collection efficiency is being achieved. This is consistent with the EMS goal, therefore only periodic updating of the results by DNR needs to conducted in order to confirm these results over time.

   b. LFG collection efficiency reported herein is likely higher, due to: 1) methane normalization that is not factored into the flow rates; 2) Sauk County's actual LFG collection rate is not factored into the flow rates; 3) the qualitative nature of modeling can bias gas generation estimates high; and 4) no accounting for capture efficiencies that can occur in landfill covers.

   c. Considering that the LFG collection efficiency continues to rise, current WDNR rules are working and achieving improved environmental protection.

   d. The EMS goal of 85% LFG collection efficiency is being achieved in 2004. Raising the EMS goal to higher levels needs to carefully consider the cost to collect the remaining LFG as compared to the environmental protection that collecting such a small amount of LFG will provide.

   e. As stated above, while some small amounts of LFG may be escaping collection, the LFG may not be emitted to the atmosphere. Other authors have reported that emissions from landfills can also be controlled by soil covers that oxidize the

LFG before it enters the atmosphere, thereby reducing emissions. Oxidation of LFG in the cover soils needs to be considered in the future EMS plans. Also, surface emissions monitoring performed to meet NSPS requirements consistently show surface concentrations of methane near background levels.